



# A Systems Engineering Approach to the Design of Energy and Resource Efficient Homes

## The Building America PartnerProgram

of the

Home Builders Association of Central New  
Mexico



# A Building America home is a home that...

---

- creates **energy efficient** environments that:
  - are affordable to operate
  - use materials to their maximum potential
  - minimize or eliminate waste
- creates **healthy** environments
- creates **comfortable** environments that are:
  - aesthetically pleasing
  - plenty of day-lighting
  - draft-free
- creates **durable** environments that are:
  - built to last
  - provide moisture control and forgiving building envelopes

# Key Program Components

---

- Energy Conservation
- Improved Indoor Air Quality
- Water Conservation
- Conservation of Building Materials
- Solid Waste Reduction
- Performance measured by field testing

# Performance Criteria

---

- Energy Conservation - Building Envelope Systems
  - Maximum Energy Consumption - **Energy Star** Standards
    - The house will use at least 30% less BTU's for heating, cooling, and hot water, than a like sized reference house that meets the 1995 Model Energy Code for the location (based on computer simulations using approved modeling program such as REM Design)
  - Envelope Leakage
    - Less than 2.5 sq. in. of leakage area per 100 sq. ft. of envelope surface area (CGSB @ 10 Pa)

# Performance Criteria

---

- Energy Conservation - Mechanical Systems
  - **Refrigerated air conditioner** unit with a minimum of SEER 12
  - **Radiant slab heat systems** require min. R-10 insulated slab perimeter
  - **Distribution of conditioned air**
    - Forced air systems that distribute air for heating and cooling will be designed to provide balanced airflow to all conditioned spaces and zones. Inter-zonal air pressure differences will be limited to 3 Pa
      - Duct systems to be located inside the conditioned space Ductwork leakage to the exterior for ducts distributing conditioned air will be limited to 5.0 percent of the total air handling system rated air flow at high speed determined by pressurization testing at 25 Pa

# Performance Criteria

---

- Improved Indoor Air Quality
  - **Dilution with controlled mechanical ventilation**  
Supply outside air @ 10cfm per person/occupancy based on # of BR + 1, i.e. 3BR House = 40CFM)
  - **Filtration** with filters that meet ASHRAE 52. 1 and 2 standards
  - **Source Control**
    - Design, build and operate homes for dry foundations
    - Use only sealed combustion or power vented combustion appliances to be installed in occupied spaces
    - Gas cook-tops and gas ovens must be installed in conjunction with exhaust fans vented to the outside
    - Use low-VOC paints, sealants, caulks, and finishes

# Performance Criteria

---

- Water Conservation
  - demonstrated water conservation at 20% below regional baseline with all of the following:
    - shower heads that use 2.5 gallons per minute or less
    - faucets that use 2.0 gallons per minute or less
    - Energy Star dishwasher (use at least 13% less energy than minimum federal standards.)

# Performance Criteria

---

- Conservation of Building Materials
  - demonstrated resource conservation techniques, at least one of the following:
    - advanced framing (framing member conservation)
    - engineered lumber and sheet goods in lieu of dimensional lumber and plywood



# Performance Goals

---

- **Solid Waste Reduction Through Recycling**
  - demonstrated solid waste reduction plan, at least one of the following:
    - job site framing lumber reuse or recycling
    - job site drywall recycling
    - job site cardboard and paper product recycling
    - request minimized packaging from suppliers

# Cost Trade-Offs

---

## Key Concepts

### Cost Trade-Offs

Improve Building Envelope (+)

Downsize Mechanical Equipment ( - )

Total Cost

Remains the Same or Costs Less

# Example-Building Envelope Characteristics

Ceiling	R-38 flat attic
Walls	R-23 24"o.c. with 1/2" fiberboard sheathing and asphalt impregnated building paper exterior with OSB at corners
Foundation	Slab with R-5 perimeter insulation
Windows	Double glazed with vinyl frame, low-E $U=0.36$ , $SHGC=-0.45$
Infiltration	2.5 sq. in. leakage area per 100 sq. ft. envelope

# Example - Mechanical Systems Characteristics

---

Heat	75% AFUE combo system inside the conditioned space
Cooling	12 SEER A/C
DHW	0.57 EF water heater in garage
Ducts	In dropped conditioned ceiling
Leakage	None to outside
Ventilation	AirCycler™ supply-only system

## Example of Estimated Annual Energy Use Typical One Story 1200 sq. ft. house - Albuquerque, NM

---

[Mbtu = 1,000,000 Btu]

Space Heating	29.6	Mbtu	\$125
Space Cooling	6.3	Mbtu	\$150
Water Heating	28.8	Mbtu	\$122

Design loads: kBtu / hr

Heating 18.0

Cooling 14.5

---

**\$397** Annual heating, cooling and hot water

**\$ 33 Monthly heating, cooling and hot water**  
(calculated using utility rates as of 10/00)

Reduced carbon emissions by 7,725 pounds per year

Weather data for Albuquerque, New Mexico:

Winter design temperatures: indoor 72°F; outdoor 16°F

Summer design temperatures: indoor 75°F; outdoor 94°F

# Advantage to Homeowner

---

- Improve Health and Safety
  - Provide ventilation strategies
  - Exercise source control
- Increase Energy Efficiency
  - Increase affordability
  - Improve comfort
- Reduce Resource Use
  - Increase durability

# Advantages to Builder

---

- More **durable** home -less call backs
- More **comfortable** home -less call backs
- Predictable lower utility bills
- Allows innovative marketing & financing

# System Improvements

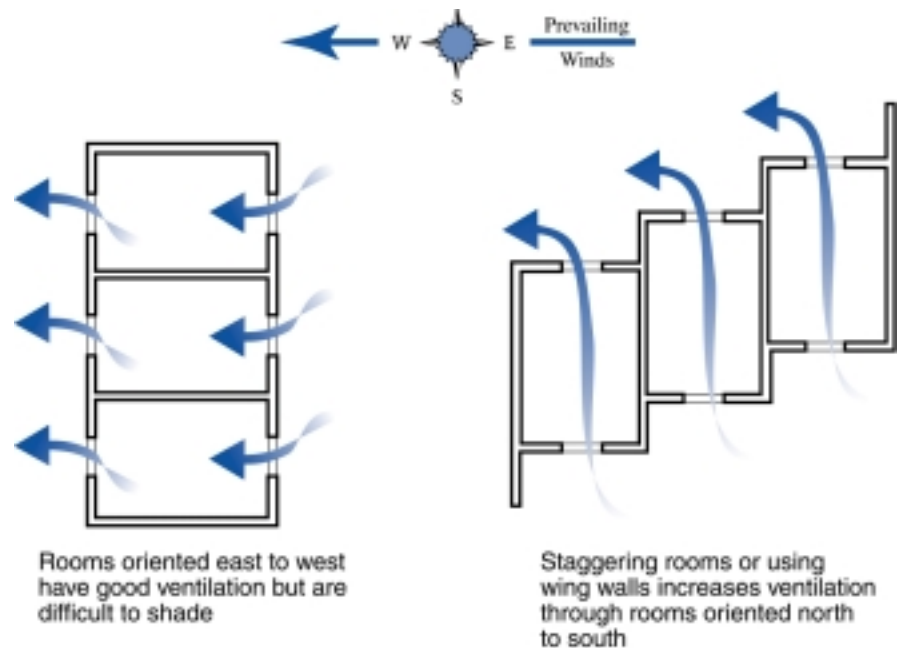
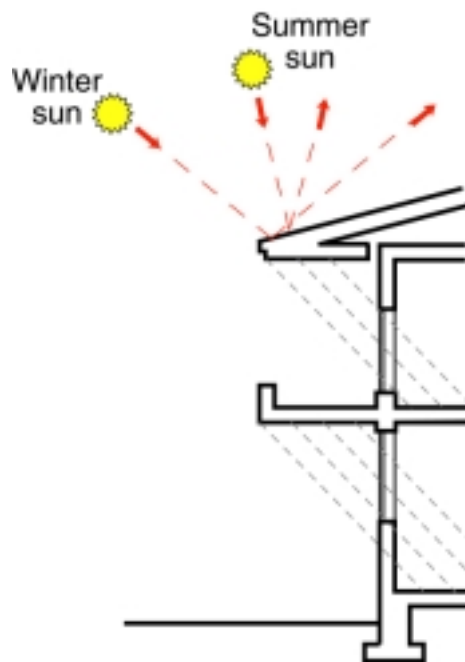
---

- Building Envelope Design
- Structural or Framing Systems
- Building Enclosure (Air Flow Control)
- Insulation Systems
- Mechanical Systems
- Airflow Distribution Systems



# Building Envelope Design

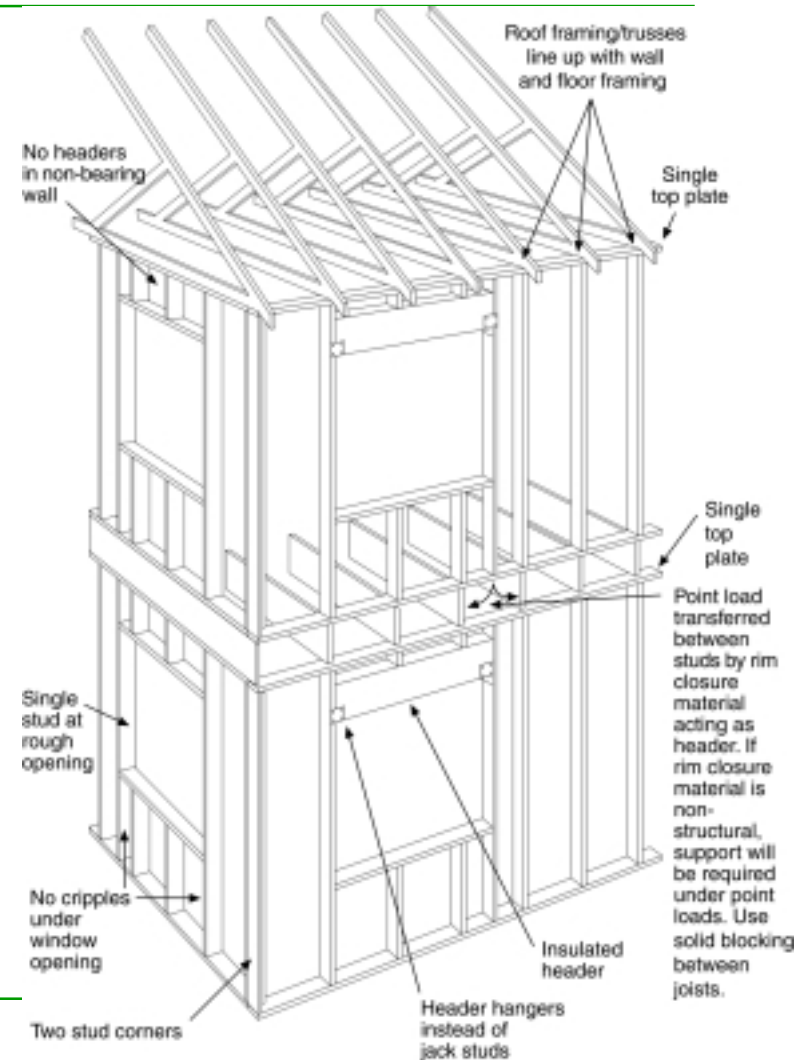
- Windows are placed for optimal **daylighting** and **passive ventilation** opportunities
- Shading provided to protect against **overheating**



# Advanced Framing System

## Framing Plan

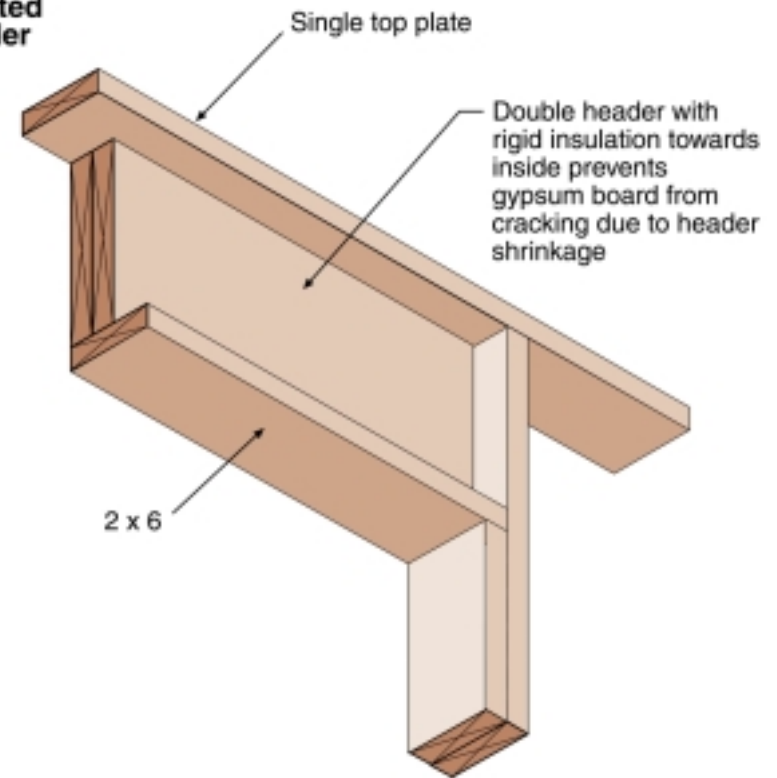
- Use 2x6 @ 24" o.c. with stack framing
- Most efficient use of wood as a structural system — **reduces waste**
- Allows more wall depth for additional insulation than 2x4 @ 16" o.c.
- Reduces thermal bridging of wall elements (total percentage of framing thermal bridge **goes down from 20% to 10%**)



# Advanced Framing System

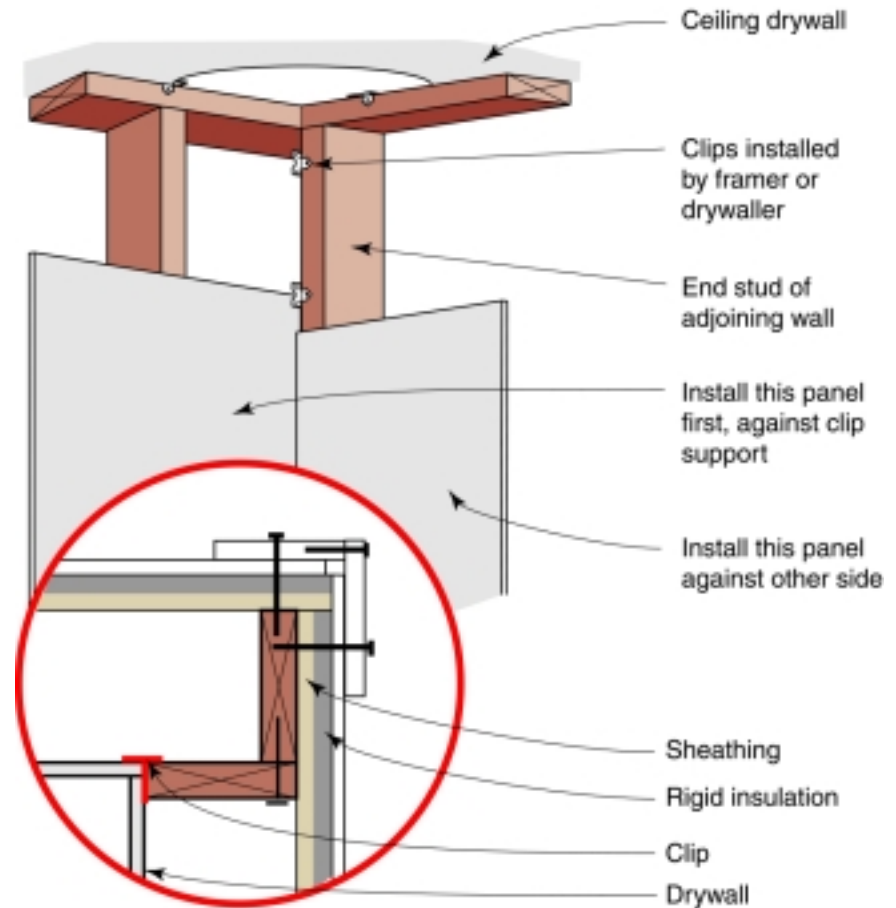
- Insulated headers
- No header necessary at non-bearing walls

Open insulated  
double header



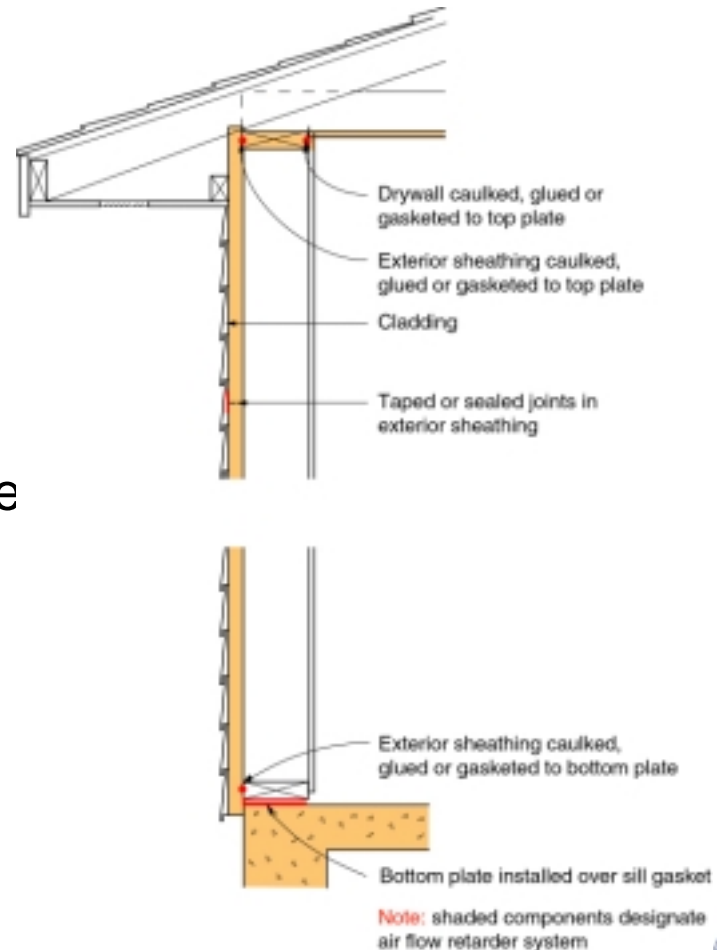
# Advanced Framing System

- Drywall clips allow for better installation with less drywall cracking



# Air Flow Retarder System

- **Exterior**
  - 1/2" fiberboard sheathing with seams taped with #15 asphalt impregnated building paper installed shingle fashion
  - 1/2" OSB at corners as needed for shear



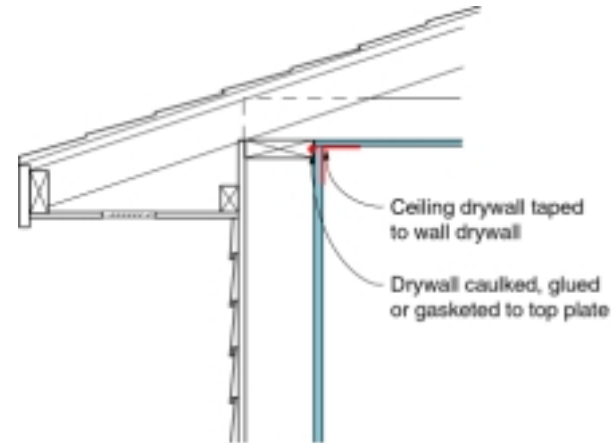
# Air Flow Retarder System

- **Interior**

- ADA

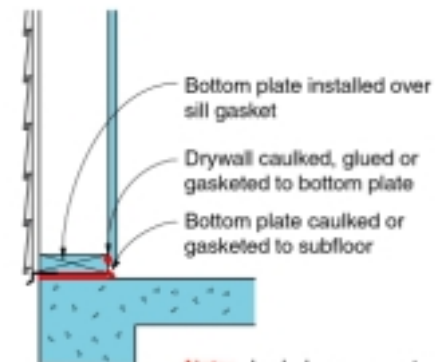
- Air Drywall Approach

- drywall glued to top and bottom plate



- **Foundations**

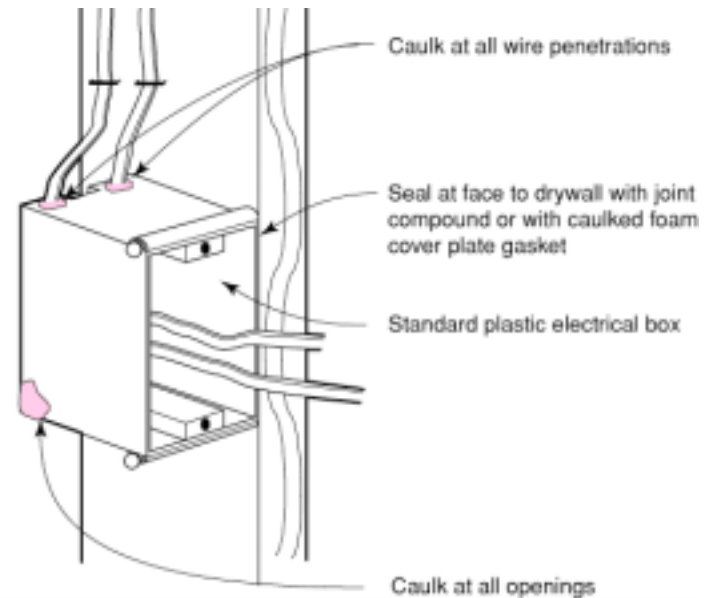
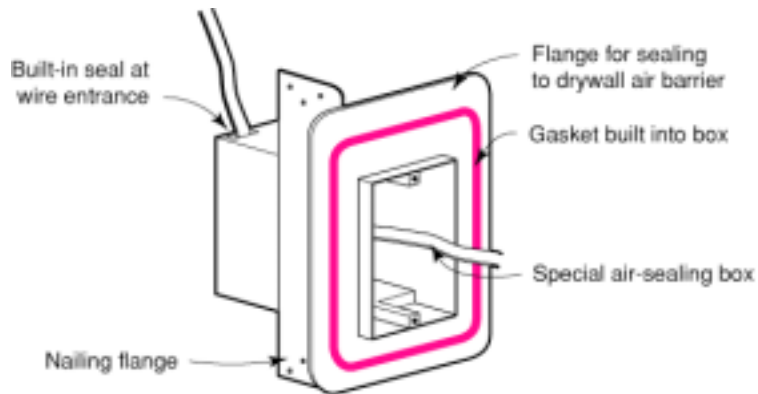
- Gasket at sill plate connections to foundation
  - Sealant at slab foundation wall intersection



**Note:** shaded components designate air flow retarder system

# Air Flow Retarder System

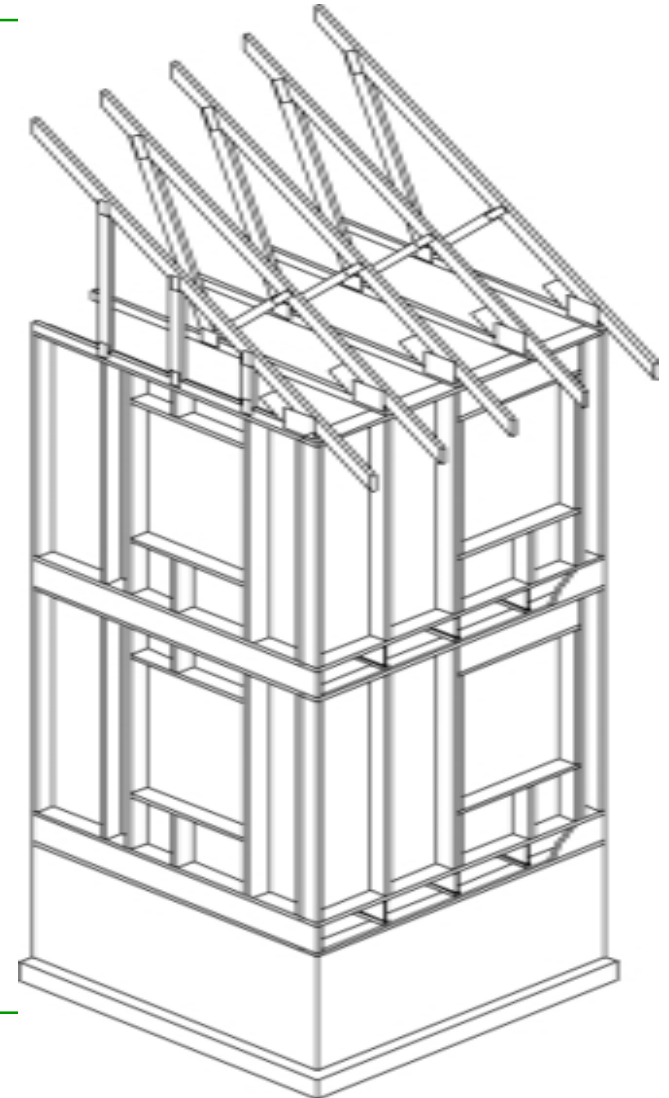
- Airtight electrical boxes



# Thermal Envelope System

---

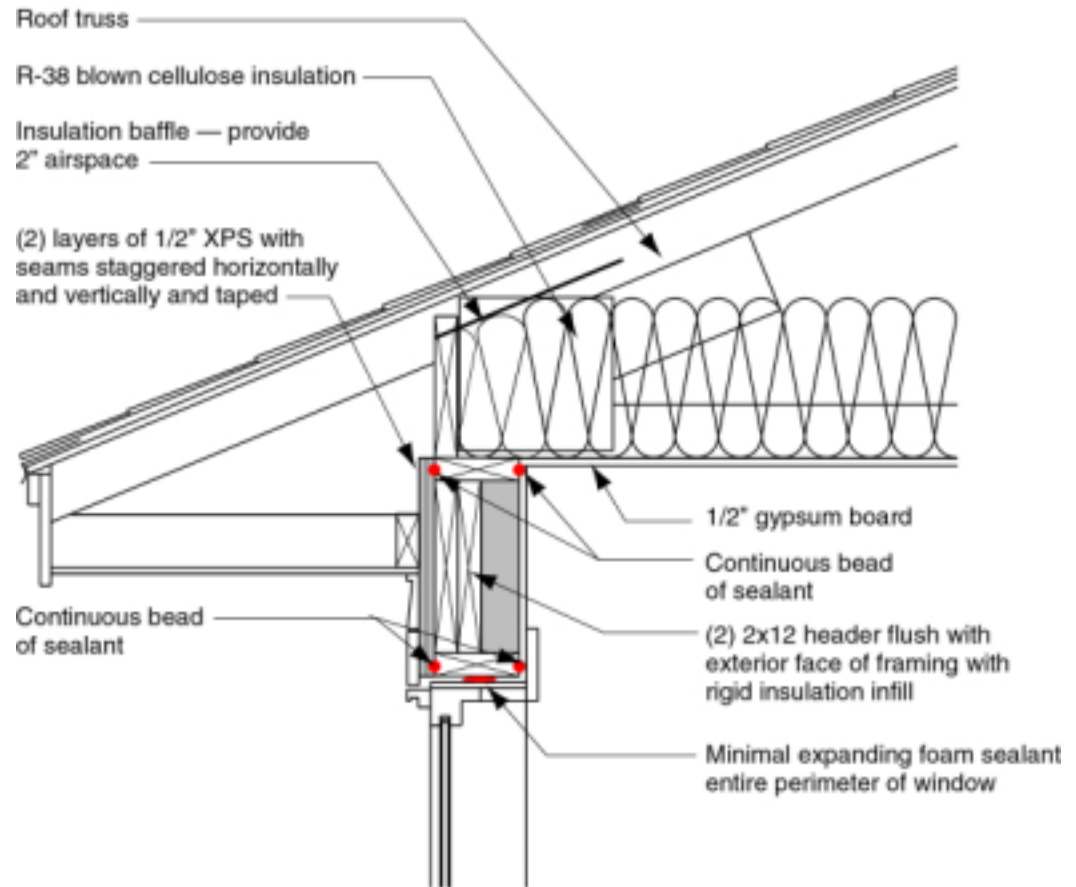
- 2 x 6 @ 24" oc **walls** allow for increased wall insulation
- Less thermal bridging  
(fewer framing members)





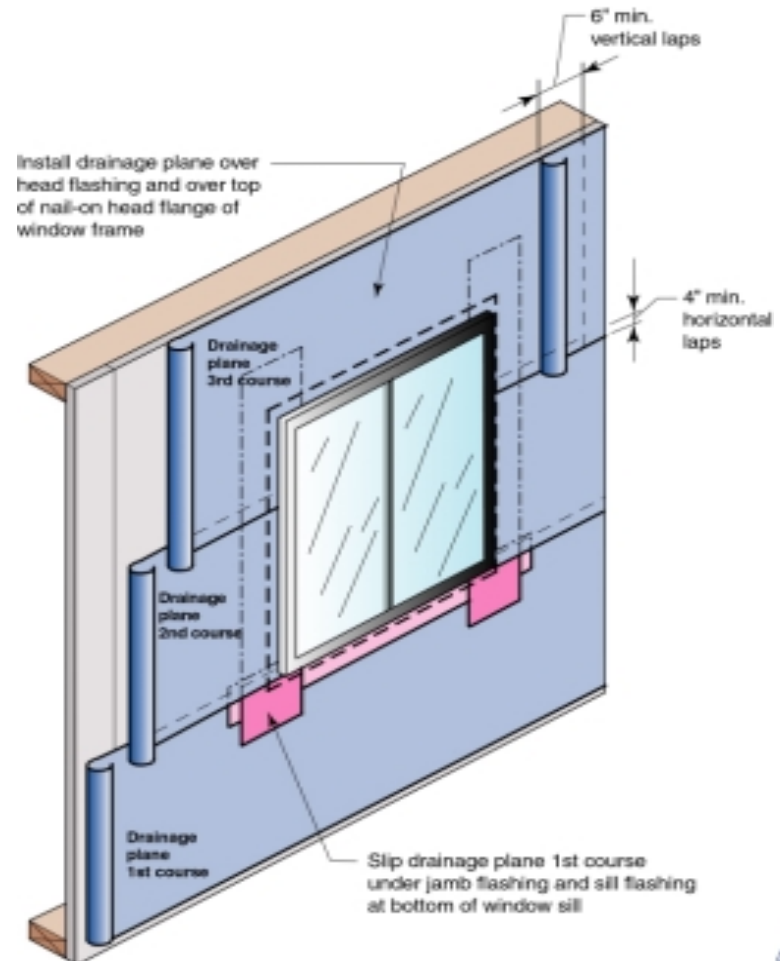
# Thermal Envelope System

- Increase truss depth for **roof insulation**



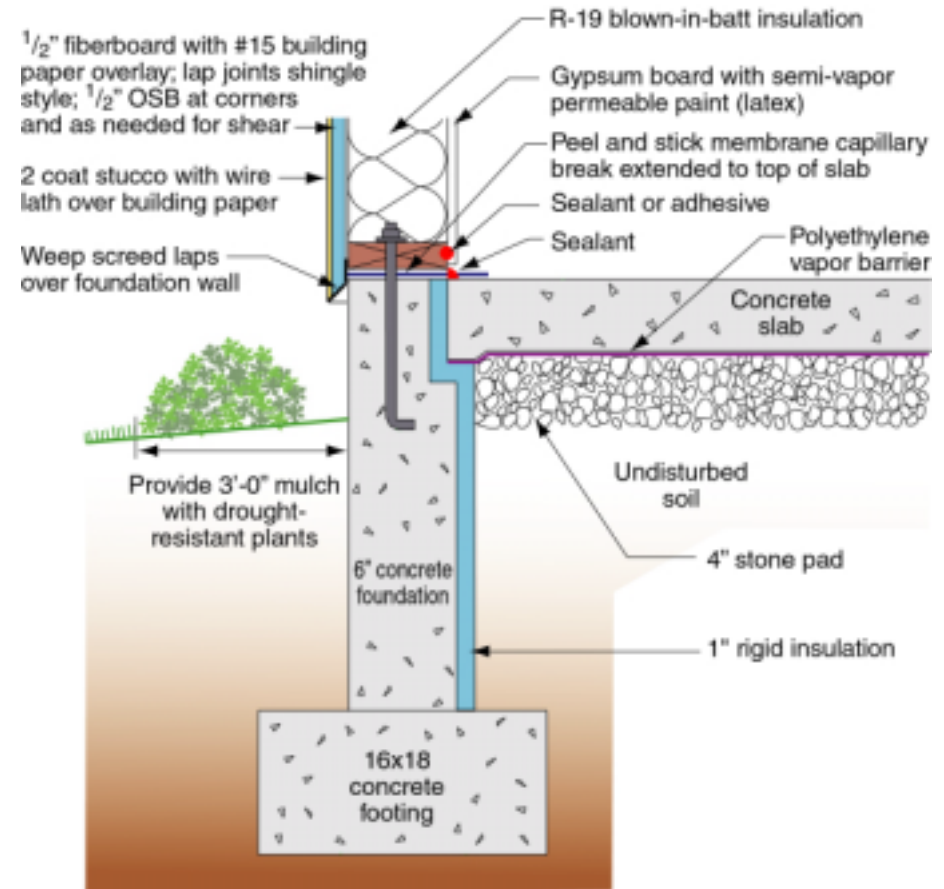
# Thermal Envelope System

- High performance windows
- Sill wrapped with membrane for moisture protection



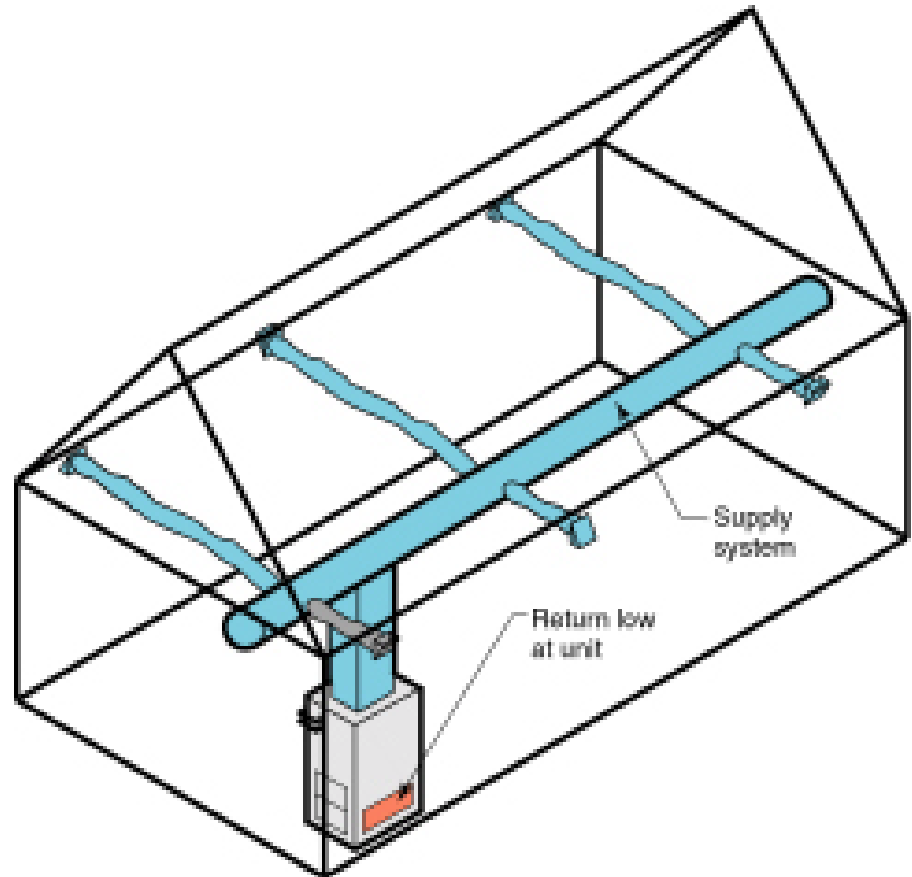
# Foundation System

- Concrete slab with 1" XPS perimeter insulation



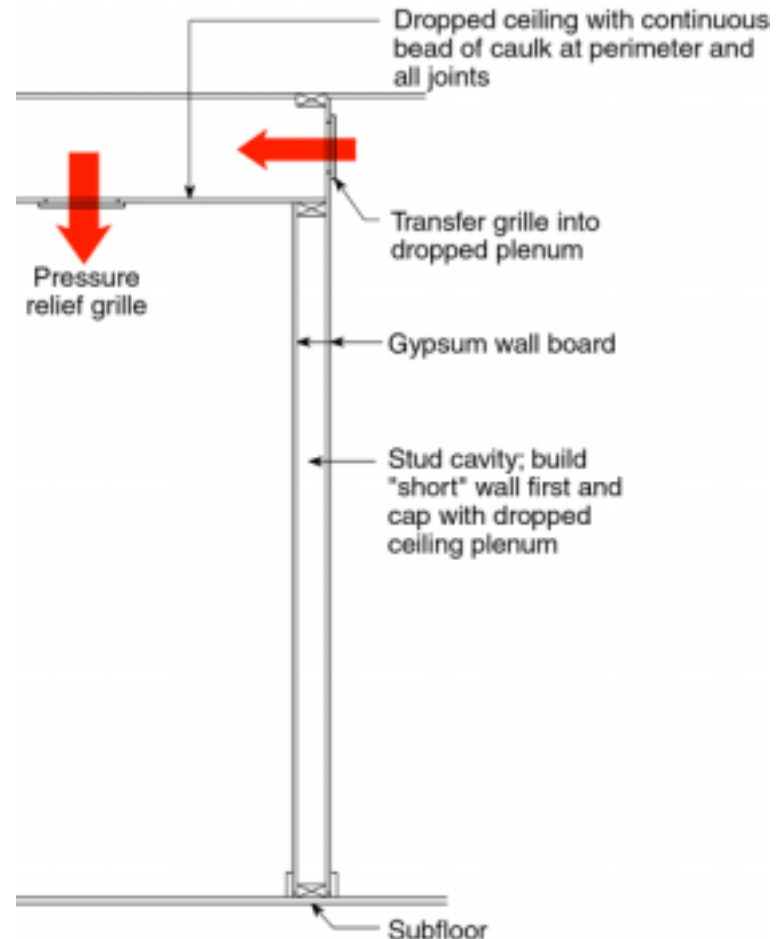
# Air Distribution System

- Innovative **ductwork** system
- **Ductwork located inside** of the building envelope in the dropped plenum (i.e. not in vented attics, exterior walls, attached garages)



# Air Distribution System

- All bedrooms have transfer grilles through interior partition walls into the dropped ceiling plenum for pressure equalization. The dropped plenum has a pressure relief grille located in the hallway.
- All doors are undercut 1"



# Central-fan-integrated Supply Ventilation

## • Interior closet or basement configuration

- Outside air is supplied through a 6" insulated duct to the central return
- AirCycler™ control brings in outside air periodically even when the air handler is not on

